ITS-I

Test station for evaluation of image quality of image intensifier tubes

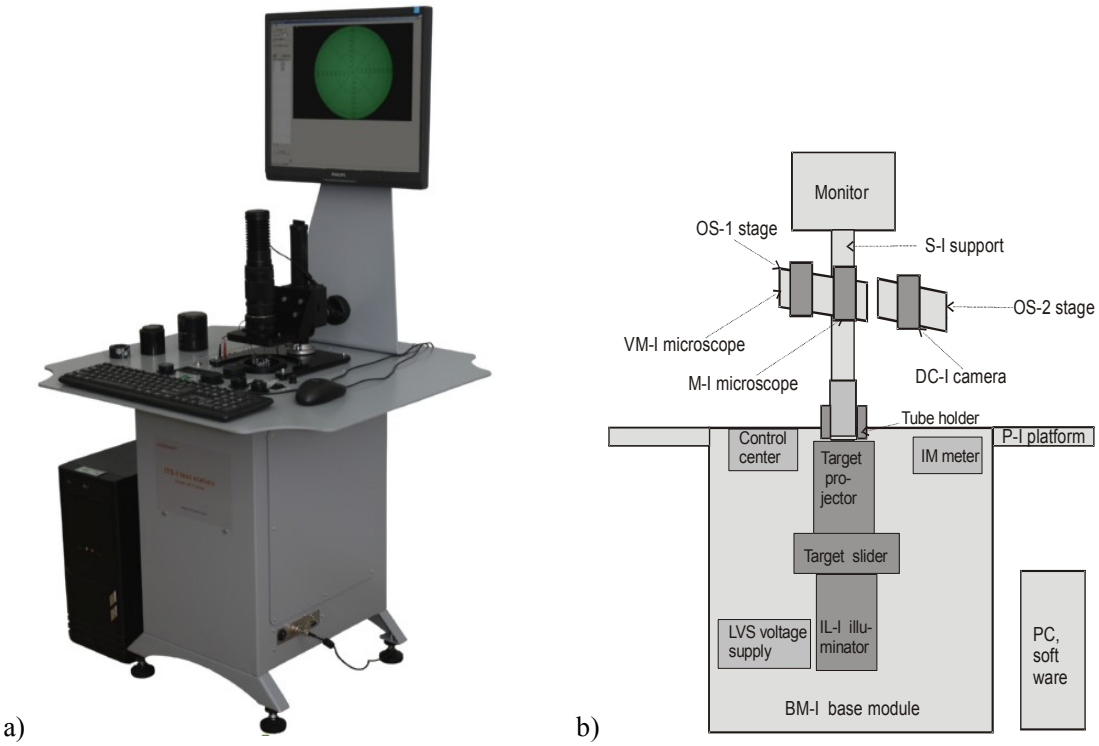

Fig. 1. Photo of the ITS-I test station: a)photo, b)block diagram

BASIC INFORMATION:

Image intensifier tubes are the most important modules of night vision devices that play crucial role in defence/security/industrial applications.

Technology of manufacturing of image intensifier tubes is very difficult and performance parameters of modern image intensifier tubes varies even within the same technological process. Next, test report offered by manufacturers cannot be fully trusted because there are some differences in test methods used by different manufactures. Further on, there are literature sources presenting conflicting claims of different manufacturers. It is quite common to find on the world market two night vision devices (or two image intensifier tubes) of the same data sheet parameters but of totally different image quality. Inverse situation is possible, too. Due to reasons mentioned above testing image intensifier tubes is of critical importance for both their manufacturers, manufacturers of night vision devices (NVDs) and final users of NVDs.

Testing of image intensifier tubes is typically done according to methods recommended by US MIL standards. These test methods refer to testing potted tubes after encapsulation. There are however some projects when more detail testing is needed using non-MILs methods or bare tubes before encapsulation are to be tested.

Inframet is a top leader in equipment for testing image intensifier tubes and offers a series of high tech test stations. These stations can be divided into three main groups optimized for different applications: ITS series stations, IRAD test stations, IPAS test stations.

ITS series stations are developed for testing potted image intensifier tubes using typical test methods recommended by MIL standards. ITS-P station enables measurement of photometric parameters, ITS-I station enables measurement of imaging parameters, ITS-R station enables measurement of reliability parameters, and optional ITS-IP enables measurement imaging and most important photometric parameters. These stations are optimal for great majority of users of image intensifier tubes.

This data sheet presents technical parameters of ITS-I station that enables measurement of image quality parameters of image intensifier tubes. The ITS-I station projects images of some standard targets to tube photocathode plane and measures distortion of the output images of these targets created at the tube screen. The stations can optionally enables also measurement of some photometric parameters. Bare tube can optionally be tested, too.

ITS-I

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1 Design concept

ITS-I station projects images of some standard targets to tube photocathode plane and measures distortion of the output images of these targets created at the tube screen. As shown in block diagram (Fig. 1b) ITS-I station is built from three main groups of blocks:

1. BM-I base module (light source, set of targets, image projector)
2. Set of tools for image evaluation (VM-I video microscope, DC-I digital camera, M-I microscope and manual optical stages)
3. PC set and software (PC, frame grabber and software for semi-automatic evaluation and recording results: TAS-I software, ITS Display software, MC Viewer software).

BM-I module project images of some standard targets to the photocathode of the tested tube. The tube generates at its screen a distorted copy of the original image created at the photocathode. The distorted copy image is later analyzed using a set of tools for image evaluation: a)VM-I video microscope, b)DC-I digital camera, c)classical M-I microscop and d)optional luminance probes. PC set and software (PC, frame grabber, TAS-I , ITS Display, MC Viewer) enable capturing and analysis of images generated by VMI video microscope and DC-I camera.

Resolution (center, peripheral, high level) of image intensifier is typically measured by analysis of images of USAF 1951 target generated by VM-I video microscope. This is subjective analysis where final decision is made by human observer but the observer is supported by software (TAS-I computer program and MRC computer program). Another option is measurement of resolution using classical microscope method (M-I microscope).

Modulation Transfer Function (MTF), Signal To Noise Ratio (S/N), Halo, Image Non-Alignment, Shear Distortion, , Image Inversion, Magnification are measured semi-automatically using TAS-I computer program by analysis of images generated by VM-I video microscope.

Dark and bright spots, Output Brightness Uniformity, Gross Distortion, Multi-Multi Pattern Noise, Multi-Boundary Pattern Noise, Temporal Distortion and measured semi-automatically using TAS-I computer program by analysis of images generated by CD-I camera.

The earlier mentioned test concept refer to testing typical potted image intensifier tubes. If additional set of three HVP power supplies is delivered and BM-I base module modified then ITS-I station can enable testing both potted and bare tubes.

Test capabilities of ITS-I station are generally limited to measurement of imaging parameters. However this station can be modernized to a station ITS-IP capable to measure both imaging and photometric parameters.

2 Technical parameters

2.1 BM-I base module

BM-I base module is the main module of the ITS-I station. BM-I module in general serves as:

1. light source (IL-I illuminator)
2. target projector
3. source of low voltage power supply for the tested tubes
4. holder for the tested tubes
5. control center of the mentioned above light source, voltage source and target slider; display for the illuminance and the target projector, communication with PC

Table. 1. Parameters of BM-I base module

IL-I illuminator	
Light Source	1)halogen 2850K color temperature source 2)monochromatic 595 nm light source
Illuminance range	20 µlx to 2lx (standard) – 200lx -option
Regulation resolution	up to 2 µlux (at low intensity range)
Regulation type	continuous (any value can be set within the regulation range)
Regulation mechanism	manual
Regulation stability	better than 2% of the set value
Illuminance uncertainty	better than 5% of the set value
Target projector	

Targets	single multi-pattern target having the following patterns: USAF1951 pattern, edge/slit pattern, pinhole pattern, tube diameter pattern, gross/shear distortion pattern, uniform/spot pattern
Resolution of target projector	≥400 [1p/mm]
Target slider	Manual
Tube holders	
Mechanical holders	MX-10160, MX-10130, MX-11620, MX-9444 or equivalent (other types possible, too)
LV power source	
type	DC
voltage	2.7 V (option: regulation from 2V to 3.5V)

2.2 Tools for image evaluation

Table. 2. Parameters of tools used for image evaluation

VM-I video microscope	
Type	high resolution, high sensitivity CCD camera integrated with custom macro objective, custom image processing electronics (linearized response, improved temporal stability, increased apparent frame rate)
Sensitivity	1mlx
Image resolution	768 x 576
Field of view	1,47 x 1,2mm
Magnification (depends on monitors settings)	>100
Resolution of macro objective	>354 lp/mm
DC-I digital camera	
Type	High resolution digital still camera
Depth of focus	Over 3.9 mm (optimized for testing tubes with curved screens)
Image resolution	3072 x 2048
Field of view	Dual FOV (optimized for 18mm and 25 mm II tubes)
Minimal Field of View	28.5 x 19 mm
Pixel	9.3 μm (at minimal FOV)
Image transfer	USB 2.0
M-I microscope	
type	mono
visual magnification	50x or 10x (other magnifications optional)
resolution	>226 lp/mm

2.3 PC and frame grabber

Table. 3. Basic parameters of the PC and the frame grabber

PC	
description	Typical desktop PC
modules	PC main unit, monitor, keyboard, mouse
memory	1024 MB RAM DDRAM (at least)
Processor	Intel Pentium G645 or better
graphics card	AGP 64 MB GeForce4 (or better)
monitor	Minimal resolution 1280×1024@75 Hz.
Hard disk	At least 500GB
Frame grabber	

Capture resolution (at 25/30 Hz)	768 x 576 (PAL) 640 x 480 (NTSC)
Input formats	PAL, NTSC, USB 2.0
Capture quality	Non-noticeable degradation of image quality
SNR	> 256

2.4 Test software

There are three computer programs that are offered by Inframet as parts of ITS-I test station:

1. ITS Display program,
2. TAS-I program,
3. MC Viewer.

ITS Display is a computer program that keeps communication between BM-I base module and PC. Program enables acquisition of data about input illumination at photocathode plane and output luminance at tube screen plane. It is used for semi-automatic measurement of optional photometric parameters (luminance gain, saturation level and EBI).

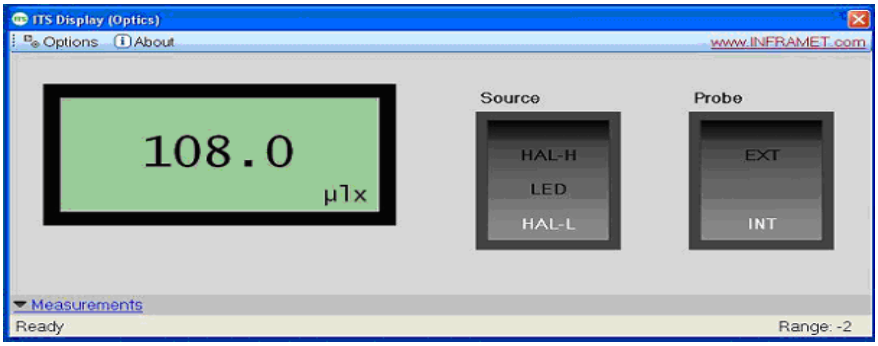

Fig. 2. Control window of ITS Display program

TAS-I is a computer program that enables the following functions:

1. Acquisition of the output images generated by VM-I video microscope
2. Acquisition of the output images generated by DC-I digital camera
3. Calculations of the following characteristics of the tested II tube: MTF, Signal To Noise Ratio (S/N), Blemishes, Output Brightness Non Uniformity, Useful tube diameter, Halo, Image Alignment, Shear Distortion, Gross Distortion, Multi-multi noise, Multi boundary noise, Image inversion.

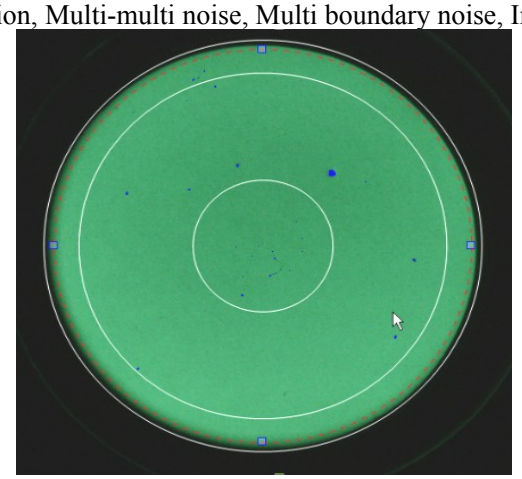

Fig. 3. Image of an exemplary tube with marked dark spots generated by TAS-I computer program. The tube area is divided into sectors according to MIL standards recommendations.

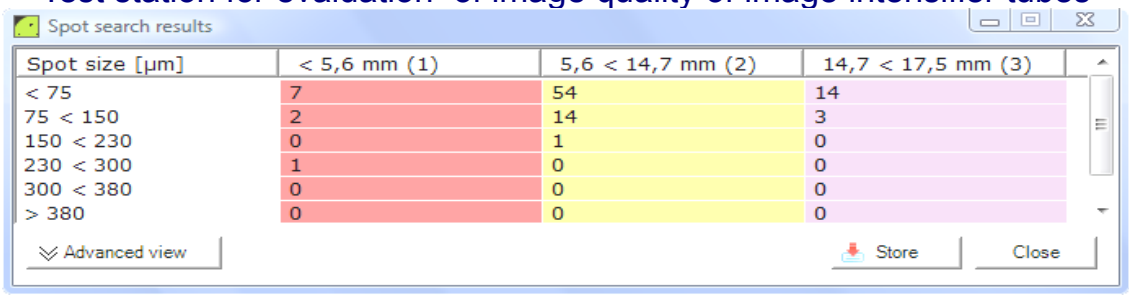

Fig. 4. Spot search results window of TAS-I computer program

MC Viewer is a computer program that enables visualization of several video sequences of images generated by tested II tubes on PC screen at the same time.

Humans can rather poorly compare images from different tubes seen at different moments of time. However, humans can very accurately compare quality of images generated by different II tubes when images are presented at the same time.

MC Viewer is particularly useful for people limited technical knowledge testing II tubes who cannot properly interpret parameters of these tubes but can easily interpret video recordings.

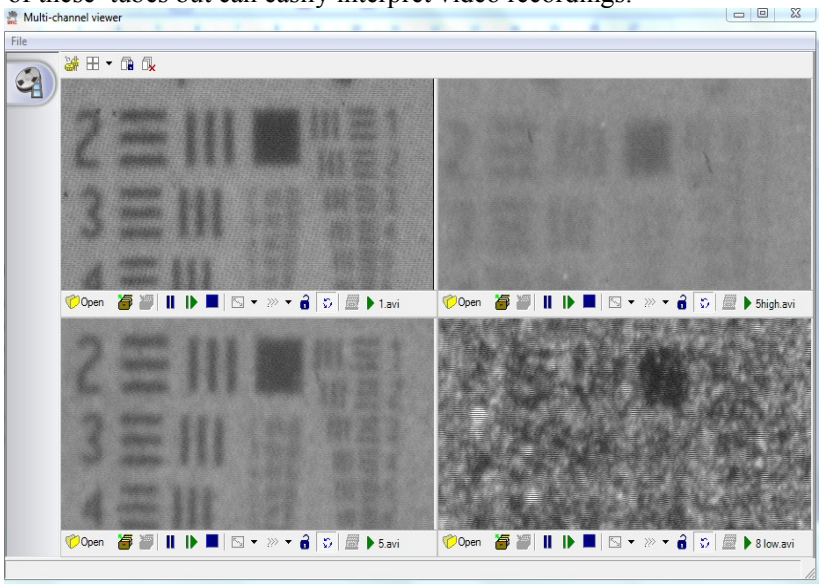

Fig. 5. MC Viewer window: video sequences of USAF 1951 target generated by four image intensifier tubes

2.5 Set of high voltage power supplies

The HVP high voltage power supply is a special power supply optimized for use in systems for testing bare image intensifier tubes. It is built as set of of four HV power modules: HVP-1 to power photocathode circuit, : HVP-2 to power MCP circuit, HVP-3 to power screen circuit, and HVP-4 – an option for some Gen3 tubes.

The HVP power supply differ significantly from typical laboratory high voltage power supplies. The HVP power modules can be connected into a cascade. Flexible grounding (any output socket of any power supply can be grounded) is possible, too. Next, the voltage regulation ranges are optimized for testing bare image intensifier tubes.

Fig. 6. Photo of HVP power supply

Table. 4. Parameters of HVP power supplies

Parameter	Value
Output voltage range	HVP-1: 10 to 1000 V - optimized for photocathode HVP-2: 30 to 3000 V - optimized for MCP HVP-3: 80 to 8000 V optimized for screen
Max output current	100 µA →HVP1, HVP2 50 µA →HVP3
Type of regulation	manual
Ripple	<0.1 % pp
Temperature stability	<300ppm/K
Humidity	Up to 90% non-condensing
Working temperature	5ºC to 40 ºC
Storage temperature	-10ºC to 65ºC

3 Versions of ITS-I test station

ITS-I test station can be delivered in different versions optimized for different customers. Both measurement capability and price depends significantly on version number.

ITS test system - version	**Capability**	**Components**
ITS-I/A1	Measurement of resolution using optical microscope	BM-I/A base module, M-I microscope, OS-1 stage, set of 3 tube holders.
ITS-I/A2	Measurement of resolution using optical microscope or video camera with software support	BM-I/A base module, M-I microscope, OS-1 stage, set of 3 tube holders, VM-I video microscope, PC, frame grabber, TAS-I/A2 program, ITS Display program, MC Viewer program
ITS-I/B	Measurement of resolution using optical microscope, semi-automatic measurement of blemishes (dark and bright spots), cathode diameter, gross distortion, output brightness non uniformity (at visible range)	BM-I/B base module, M-I microscope, OS-2 stage, set of 3 tube holders, PC, TAS-I/B computer program, ITS Display computer program, DC-I camera
ITS-I/B2	the same as in version ITS-B but additionally measurement of luminance gain and saturation level	BM-I/B2 base module, M-I microscope, OS-2 stage, set of 3 tube holders, PC, TAS-I/B computer program, ITS Display computer program, DC-I camera, LP1 luminance probe
ITS-I/C1	Measurement of resolution using optical microscope or video camera with software support, semi-automatic measurement of	BM-I/C1 base module, M-I microscope, VM-I video microscope, OS-1 stage, OS-2 stage, set of 3 tube holders, PC, frame grabber, TAS-I/C1 computer

	MTF, blemishes (dark and bright spots), halo, cathode diameter, gross distortion, output brightness non uniformity	program, ITS Display computer program, DC-I camera, MC Viewer program
ITS-I/C2	Measurement of resolution using optical microscope or video camera with software support, semi-automatic measurement of blemishes (dark and bright spots), cathode diameter, gross distortion, alignment, output brightness non uniformity, halo, rise time, decay time and phosphor decay time	BM-I/C2 base module, M-I microscope, VM-I video microscope, OS-1 stage, OS-2 stage, set of 3 tube holders, PC, frame grabber, TAS-I/C2 computer program, ITS Display computer program, DC-I camera, TP temporal probe, MC Viewer program, ITime computer program
ITS-I/D	Measurement of resolution using optical microscope or video camera with software support, semi-automatic measurement of MTF, SNR, blemishes (dark and bright spots), cathode diameter, gross distortion, output brightness non uniformity, halo, image alignment	BM-I/D base module, M-I microscope, VM-I video microscope, OS-1 stage, OS-2 stage, set of 3 tube holders, PC, frame grabber, TAS-I/D computer program, ITS Display computer program, DC-I camera, MC Viewer program
ITS-I/E	Measurement of resolution using optical microscope or video camera with software support, semi-automatic measurement of MTF, SNR, blemishes (dark and bright spots), cathode diameter, gross distortion, output brightness non uniformity, halo, image alignment, image inversion, magnification, temporal magnification	BM-I/E base module, M-I microscope, VM-I video microscope, OS-1 stage, OS-2 stage, set of 3 tube holders, PC, frame grabber, TAS-I/E computer program, ITS Display computer program, DC-I camera, MC Viewer program
ITS-I/MSR	Measurement of MTF, SNR, resolution	BM-I/MSR base module, VM-I video microscope, M-I microscope, OS-1 stage, set of 3 tube holders, PC, frame grabber, TAS-I/MSR computer program, P-I platform, S-I support, ITS Display computer program, MC Viewer program
ITS-I/MT	Measurement of MTF	BM-I/MT base module, VM-I video microscope, M-I microscope, OS-1 stage, set of 3 tube holders, PC, frame grabber, TAS-I/MT computer program, P-I platform, S-I support
ITS-I/SN	Measurement of SNR	BM-I/SN base module, VM-I video microscope, M-I microscope, OS-1 stage, set of 3 tube holders, PC, frame grabber, TAS-I/SN computer program, P-I platform, S-I support, ITS Display computer program

The codes presented above refer to versions to be used for testing potted tubes. Testing bare tubes requires additional modules: HV power supplies and tube holders. These modules can be delivered by Inframet as an additional option

4 Comparison of ITS-I and other test stations

There are other commercially available test stations that can be used for measurement of image quality parameters. Here we will compare different versions of ITS-I test stations with other commercially available test stations.

ITS-I test station represent a new generation of test stations for testing image quality of II tubes. It was developed by Inframet in 2004 year as the first commercially available single test station that enabled measurement of all image quality parameters. A few commercially available test stations were needed to do the same task. Since 2004 ITS-I test station has been significantly improved and at the same time has passed a series of tests in different countries that confirmed its capabilities as a truly modern test station that wins any practical comparison to other test stations. Here we will present some of its features that present advantages of ITS-I over other test stations.

ITS-I

Test station for evaluation of image quality of image intensifier tubes

1. Fast semi automatic measurement method. Humans are still necessary and important but they are supported by software that increase measurement speed and accuracy.
2. Possibility to record all input data (images) and measurement results.
3. Compact design of ITS-I station. Some other test stations are a collection of laboratory equipment placed on a laboratory table.
4. Due to use of special tube holders the tests do not have to be carried out in total darkness. It is enough if tests are carried out in rooms where illumination is at level about 0.5 lx that enable relatively comfortable conditions for humans.
5. Possibility to compare online video images of USAF target generated by the tested tube to video images of the USAF target generated by a standard tube at the same time on PC screen. This feature significantly improved measurement speed and accuracy of resolution by human observers.
6. Continuous regulation of illumination level. Any level from $2\ 10^{-5}$ lux to 2 lx can be set. In typical test stations only several illumination levels are available.
7. Custom designed image projector of extremely high limiting resolution (resolution over 400 lp/mm). Typical test stations use typical commercial photographic macro objectives of limited quality to project images (resolution not higher than 100 lp/mm according to data from manufacturers of photographic objectives).Medium resolution image projector can decrease accuracy of measurement of the resolution of tested image intensifier tube.

The combination of all these factors enabled us to built ITS-I test station: the best commercially available test station for testing modern image intensifier tubes.

Attention: Minor details of these specifications are subject to change without prior notice. These changes can be made due to continuous improvement of Inframet products. However, in any case the changes shall not reduce measurement capabilities of ITS-I test station.

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